

**The Dam-Break Flood:** Between Kelly Barnes Dam and Highway Road the flooded area was defined by a survey of high-water marks (figs. 9 and 10). Seventy-two cross sections were obtained. A detailed analysis of peak discharges, flood frequency, and flood profiles is presented below.

**Peak discharges and flood frequency:** The peak discharges summarized in table 2 were computed on basis of cross sections, water-surface profiles, roughness coefficients, and, at some places, bridge geometry. Peak discharge measurement sites A-G are shown in figure 10. Site H is 1.6 mi downstream from site G and not shown in figure 10.

TABLE 2.—Summary of peak discharges for flood of November 5 and 6, 1977, at selected sites on Toccoa Creek near Toccoa. See figure 10 for site locations.

Site	Drainage Area (sq mi)	Distance above mouth (ft)	Discharge (cfs)
A	3.7	58,000	830
B	4.6	53,140	980
D	4.6	53,140	1,400
C and G	4.6	53,140	2,400
E	4.6	52,940	2,400
F	4.6	48,870	14,300
G	8.6	42,280	6,380
H	25.3	20,270	3,660

<sup>a</sup> Peak inflow to Kelly Barnes Lake estimated from unit-hydrograph computations. Maximum total spillway outflow prior to dam break.

The computed peak discharge of Toccoa Creek at site A near the head of Kelly Barnes Lake, for the flood of November 5-6, was 830 ft<sup>3</sup>/s (cubic feet per second). The peak inflow of 980 ft<sup>3</sup>/s to the lake was estimated at site B by hydrograph synthesis with a rainfall-runoff model. Based on a regional flood-frequency analysis (Golden and Price, 1976) for small drainage basins, the estimated recurrence interval of this flood is about 10 years. The recurrence interval is the average time interval between actual occurrences of peak flows of a given or greater magnitude. Although the recurrence interval represents the long-term average period between floods of a specific magnitude, such floods could occur at short intervals or within the same year.

At the site of the discontinued U.S. Geological Survey gaging station on Panther Creek (drainage area, 32.5 square miles), 5 1/2 miles north of Toccoa (fig. 1), peak discharge for November 5-6 was 6,600 ft<sup>3</sup>/s. Based on a frequency analysis of 48 years of station record, this flood had a recurrence interval of approximately 15 years. The Panther Creek basin adjoins the Toccoa Creek basin.

The peak outflow of 400 ft<sup>3</sup>/s from Kelly Barnes Lake before dam failure was estimated by means of slope-area and flow-over-crest computations at sites C and G, respectively. Flow occurred in both the primary earth spillway (site C) near the left end of the dam and the secondary spillway (site G).

Although the dam-break flood undoubtedly moved downstream as a flood wave, it produced a pool-and-riffle type of flow as shown by the water surface profiles in figure 11.

Peak discharges were computed at sites A, D, E, and F using the standard slope-area computation procedure described by Dalrymple and Benson (1967). The procedure assumes steady flow conditions that obviously did not exist immediately downstream from the broken dam. The effects of unsteady flow were minimized by using short reaches for slope-area computations. Immediately downstream from sites D, E, and F, high-water profiles indicate that the flow changed from tranquil to rapid state. At these sites, peak discharges computed by the critical-depth method agree closely with those computed by the slope-area method.

Discharges were computed at Highway Road and Georgia Highway 184 (sites C and H) using a standard continuity-flooding procedure as described by Mathai (1967).

Conditions for making discharge computations were considered good at sites A and H, fair at sites B, F, and G, and poor at sites C, D, and E. Graphs showing the relation of discharge to drainage area for the observed flood, together with the 10-, 50-, and 100-year regional flood-frequency curves (Golden and Price, 1976), are shown in figure 12. No attenuation of the peak discharge was evident between the dam and Toccoa Falls College (sites D and E). Extreme attenuation occurred between Toccoa Falls College and Highway Road (sites F and G) due to increased overbank storage and rapid changes in stage. Flow at sites F and G was 60 percent and 27 percent, respectively, of the peak discharge at site E.

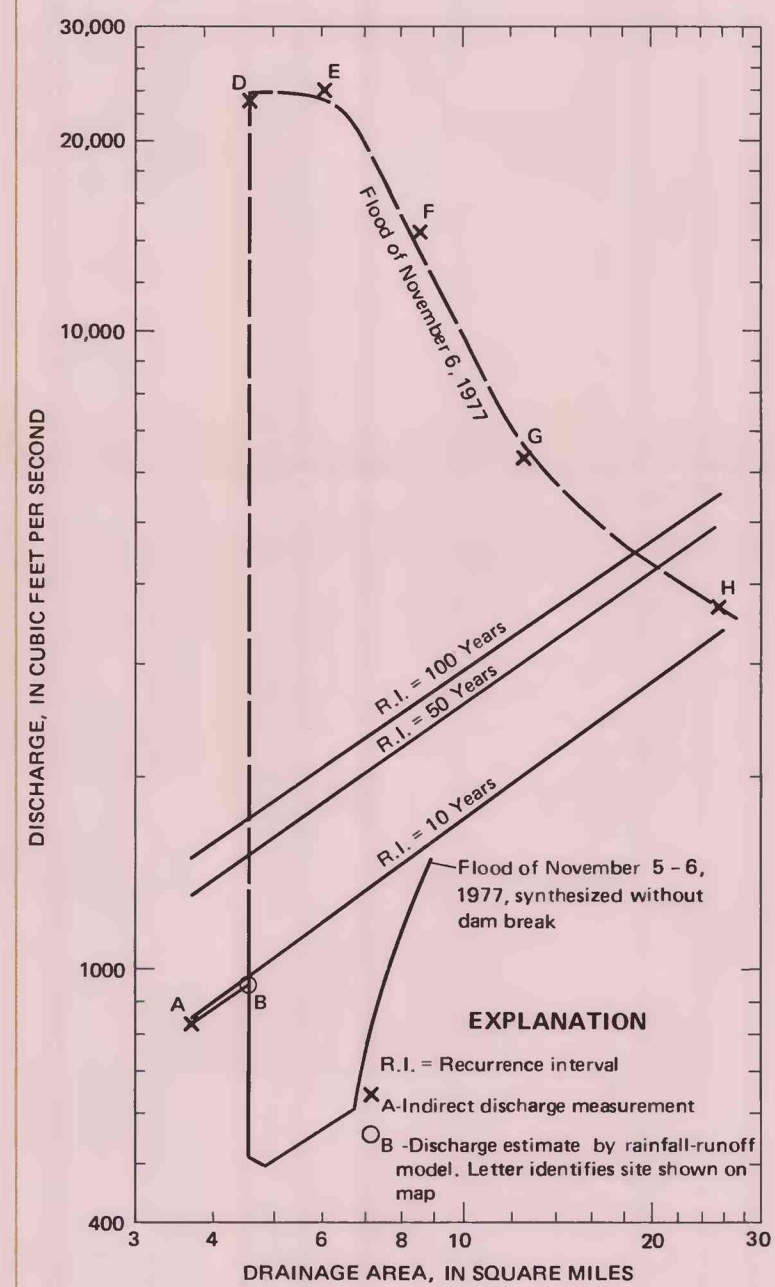


FIGURE 12.—Relation of peak discharge to drainage area for Toccoa Creek.

Because this disaster occurred at night, eyewitness accounts of the timing of the flood wave were not consistent. According to one witness, the creek was out of its bank for about an hour at Forrest Hall Dormitory, at the upstream end of the college campus. Other witnesses indicate that the flood waters were out of bank for only about 40 minutes. An estimated discharge hydrograph at Forrest Hall Dormitory, 0.7 mile downstream from the dam, based on these reports, is shown in figure 13.

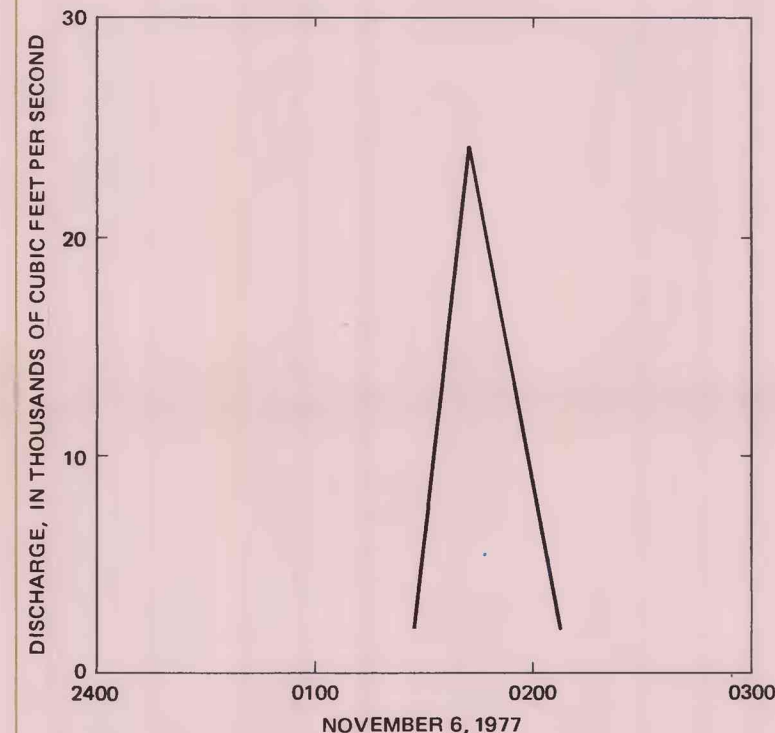


FIGURE 13.—Estimated hydrograph at Forrest Hall Dormitory, 0.7 mile downstream from Kelly Barnes Dam. Timing based on reports of eyewitnesses.

**Flood profile:** Water-surface profiles, determined from a field survey of high-water marks left by the flood of November 6, are shown in figure 11. Average depths in the main channel above Toccoa Falls were about 17 feet. Depths in the vicinity of the college ranged from about 21 feet at Forrest Hall Dormitory to 18 feet at the trailer village. Depths downstream from Georgia Highway 17 averaged about 15 feet.

Controls for pool-and-riffle flow are located near stations 517, 486, 480, and 465 and at Georgia Highway 17. These controls are at obvious valley constrictions, but some of the resulting backwater could have been caused by temporarily lodged debris. Extreme scour was evident at these controls.

Water-surface elevations on the left bank differed from those on the right bank by as much as 10 feet in the curves along the main channel because of superposition resulting from high velocities. However, even in these high-velocity areas, ponded conditions existed in nooks near the mouths of tributaries.

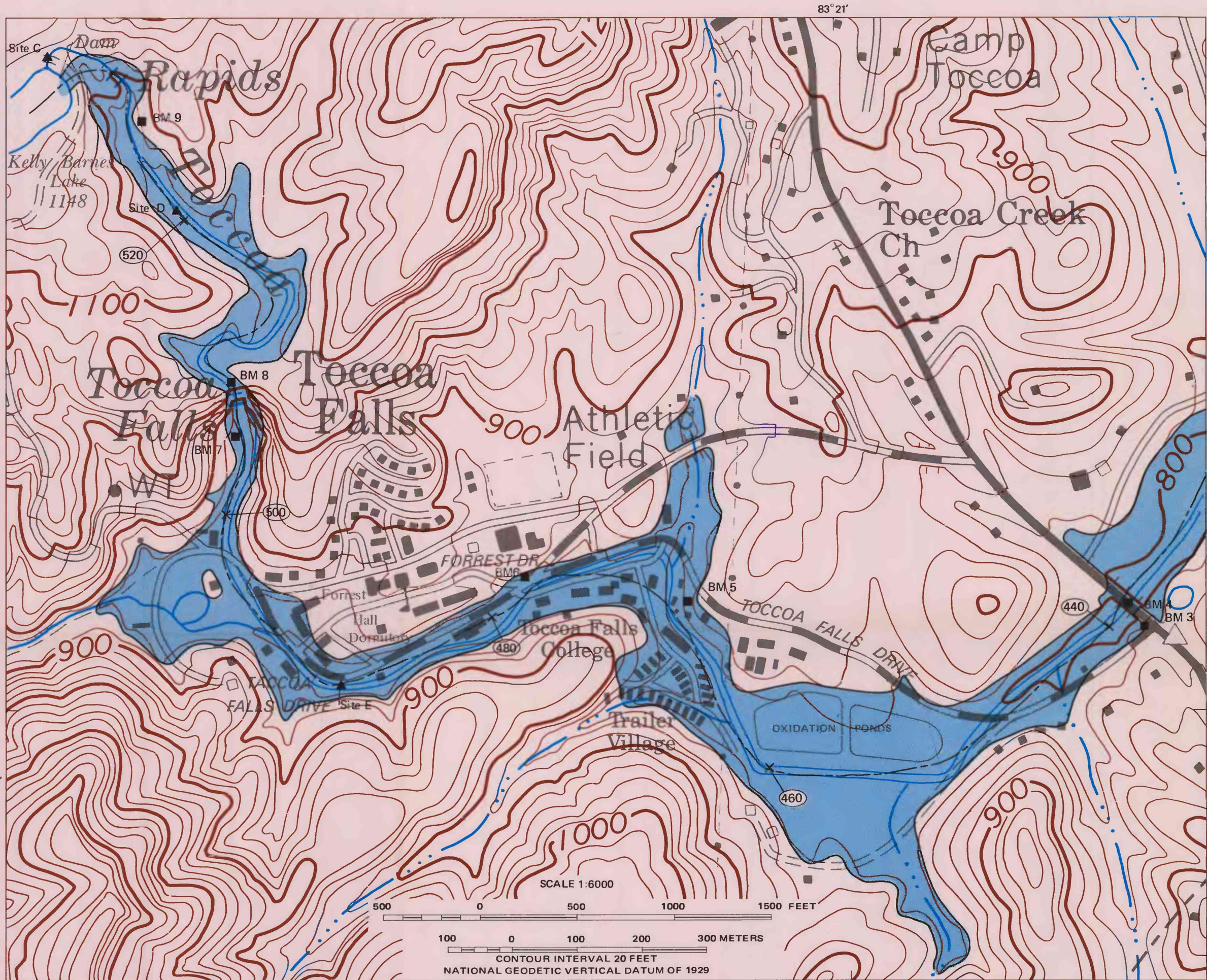


FIGURE 9.—Flood area from Kelly Barnes Dam to Georgia Highway 17.

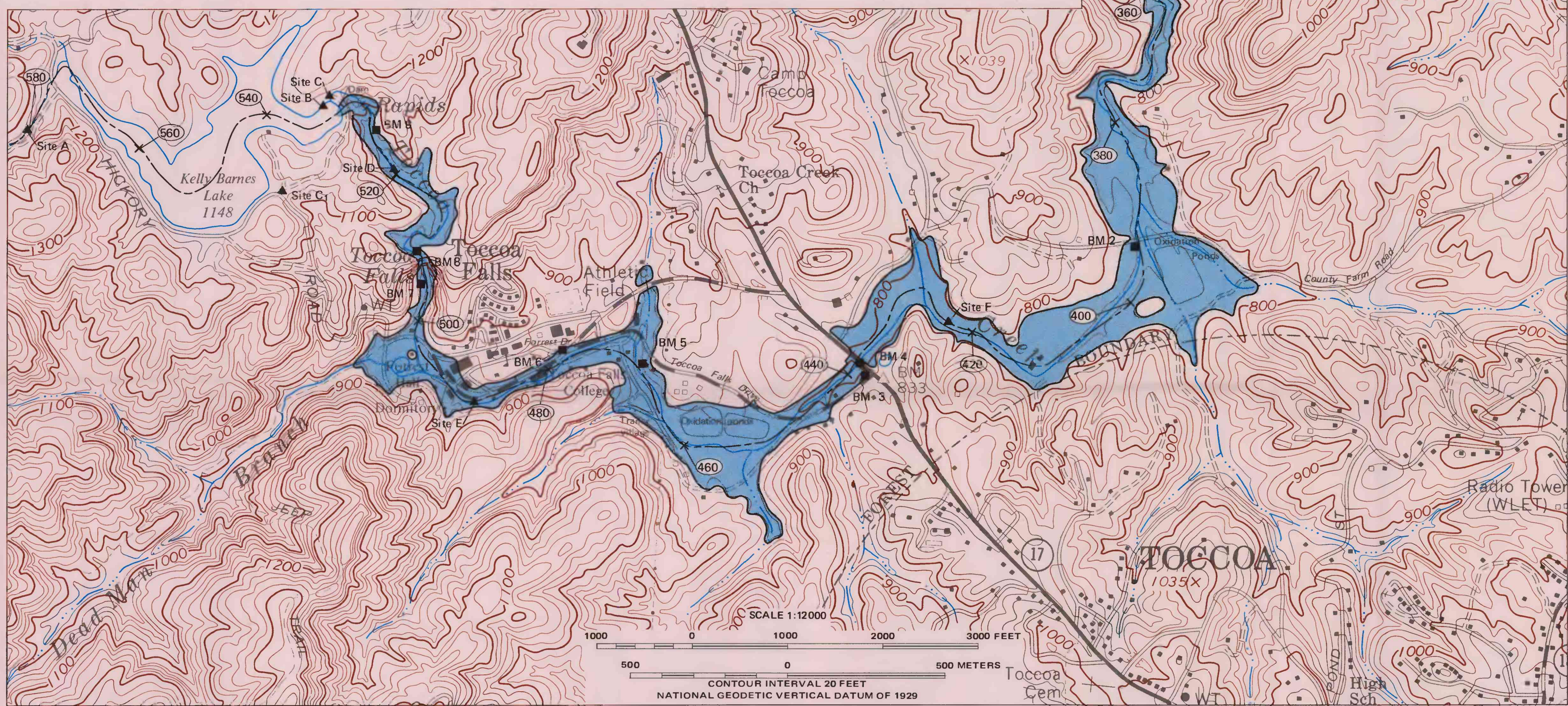


FIGURE 10.—Flood area from Kelly Barnes Lake to Highway Road.

**The Flood Without Dam Break:** Streamflow estimated by rainfall-runoff model. Computations were made using a simplified version of the U.S. Geological Survey rainfall-runoff model (Dawdy and others, 1972) to develop a hydrograph of inflow to Kelly Barnes Lake for November 5-6 (fig. 14).

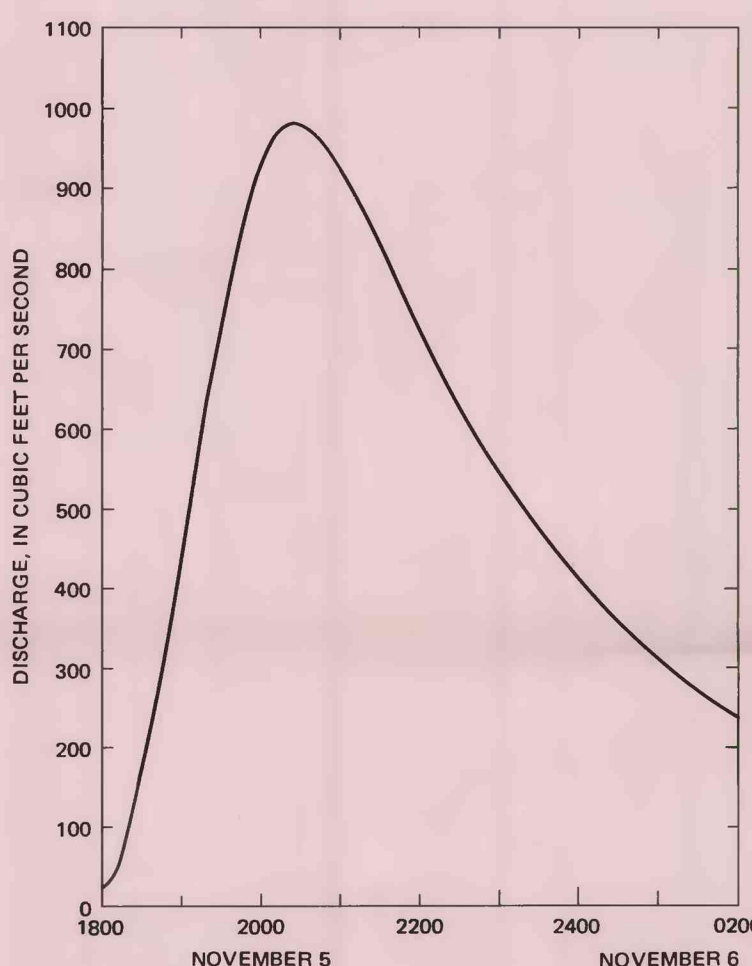


FIGURE 14.—Synthesized inflow hydrograph at site B, Toccoa Creek above Kelly Barnes Dam.

The model was calibrated by reproducing the observed discharge at site A of 830 ft<sup>3</sup>/s from Toccoa Creek into the lake. The model, with streamflow and reservoir routing techniques, was used to estimate discharges (fig. 12) in the reach between Toccoa Falls and Georgia Highway 17 that would have occurred if the dam had not broken, and also if there had been no dam.

**Profile estimates without the dam break:** Computed water-surface profiles for assumed conditions without the dam break, both with and without effects of lake storage, are shown in figure 11B. The two profiles were computed by means of the U.S. Geological Survey step-backwater routing program (Shearn, 1976) using the discharges obtained from the rainfall-runoff model. Cross sections used in the analysis were surveyed after the flood by the U.S. Geological Survey and the U.S. Army Corps of Engineers. The stream channel at these cross sections was generally scored by the flood. Thus, the computed profiles represent only the minimum water-surface elevations that would have occurred had the dam not broken, and are not representative of conditions prior to the dam break.

**Sediment:** A qualitative reconnaissance of sediment sources and sediment deposition was conducted on November 10 and 11. The operation of earthmoving equipment downstream from Toccoa Falls, however, prevented a qualitative evaluation of sedimentation conditions and limited this investigation to the reservoir and the stream channel upstream from Toccoa Falls. The following is a description of observations made during this reconnaissance.



FIGURE 15.—Sand deposit 400 feet upstream from Toccoa Falls.

The breached section of the dam was a major source of gravel (2.0-64 mm), sand (0.062-2.0 mm), and finer material. Field measurements indicate that about 13,000 cubic yards of material was removed from the dam. Other sources of sediment in this size range include soil eroded from the valley walls and reservoir deposits that were eroded during stream incision. Most of the sand and finer material was transported over Toccoa Falls. One large deposit of sand, however, occurred on the inside of a broad bend about 400 feet upstream from Toccoa Falls. The areal extent of this deposit was not measured because of debris; however, its thickness is evident in figure 15. The relative amounts of gravel transported through or deposited in the reach cannot be reliably estimated. Deposits of gravel-size material are present throughout the reach, generally intermixed with larger material or in association with debris piles.

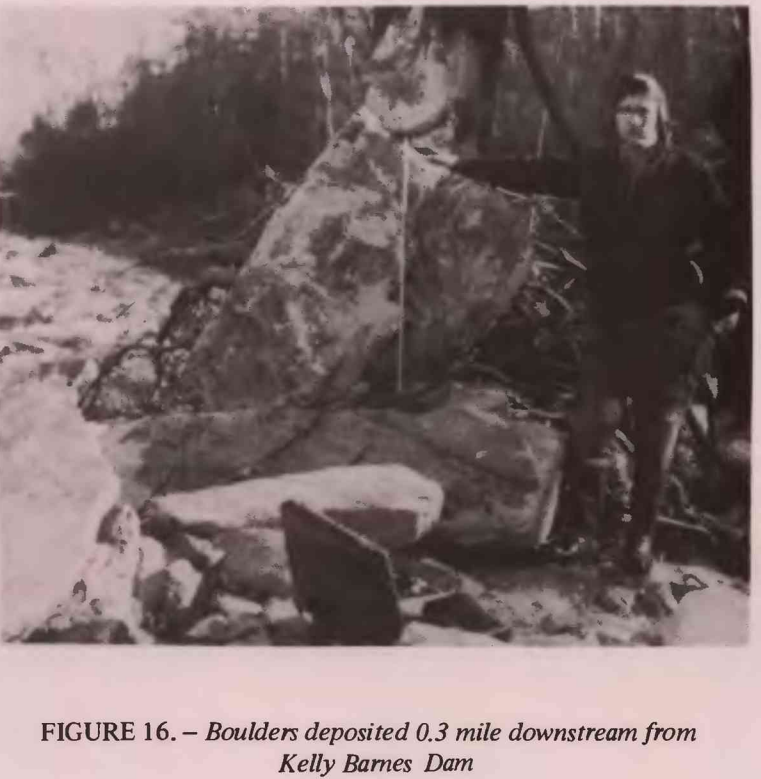


FIGURE 16.—Boulders deposited 0.3 mile downstream from Kelly Barnes Dam.

Sediment transported by the flood can be divided by particle size, source area, and mode of transport. Sand and finer material derived primarily from the breached dam, dissected reservoir deposits, and eroded soil cover were, for the most part, transported through the reach and over Toccoa Falls. These fine materials formed most of the wash load of the flood wave. Cobbles (64-256 mm) and boulders (larger than 256 mm) derived from the streambed and surrounding bedrock were moved only short distances and thus constitute the bed-material load of the stream. Gravel-size material that was derived from both the breached dam and the streambed forms a transition particle size between wash loads and bed-material load.

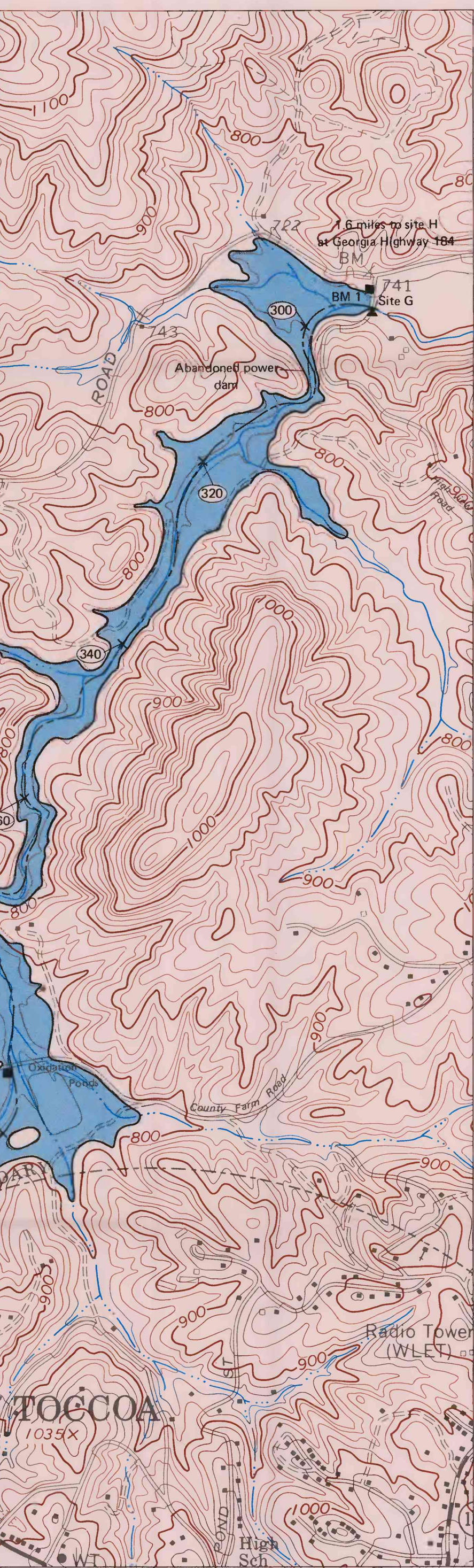
**Flood damage:** Approximately nine houses, 18 house trailers, two college buildings, and many motor vehicles were completely demolished. Four houses and five college buildings were damaged by water. Only two houses downstream from Georgia Highway 17 were damaged.

The embankment at Toccoa Falls Drive, the oxidation pond above Georgia Highway 17, and parts of the main channel were scored. Two bridges on Toccoa Falls Drive and the culvert at County Farm Road were completely destroyed. The highway embankments at Georgia Highway 17 were washed out at both ends of the bridge, and one of the bridge abutments at Highway Road was destroyed. The water-supply pipe for the city of Toccoa was broken and the city's water supply was contaminated for several days.

**Additional information:** Field survey, hydrologic, hydraulic, and other pertinent data can be obtained by contacting the U.S. Geological Survey, Water Resources Division, 6481 Peachtree Industrial Boulevard, Suite B, Doraville, Ga. 30060.

**EXPLANATION**

- Area flooded November 6, 1977
- Limit of flood of November 6, 1977
- Centroid of stream flow
- Site of indirect peak discharge measurement
- Elevation bench mark
- Station in hundreds of feet above mouth



**REFERENCES CITED**

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**FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM (SI) UNITS**

The following factors may be used to convert the inch-pound units published herein to the International System of Units (SI).

Multiply inch-pound units by	To obtain SI units
inch (in.)	25.4 millimeter (mm)
foot (ft)	0.3048 meter (m)
mile (mi)	1.609 kilometer (km)
acre	0.4047 square meter (m <sup>2</sup> )
square mile (mi <sup>2</sup> )	0.0004047 square kilometer (km <sup>2</sup> )
cubic foot (ft <sup>3</sup> )	0.02832 cubic decimeter (dm <sup>3</sup> )
acre-foot (acre-ft)	1223.08 cubic meter (m <sup>3</sup> )
cubic yard (yd <sup>3</sup> )	0.7646 cubic meter (m <sup>3</sup> )
cubic foot per second (ft <sup>3</sup> /s)	0.02832 cubic decimeter per second (dm <sup>3</sup> /s)
foot per mile (ft/mi)	0.000127 meter per kilometer

\* The factor is approved for use with the International System (SI) for a limited time. See [U.S.] National Bureau of Standards Special Publication 330, 1977 edition, page 12.

\*\* The liter is accepted for use with the International System (SI). See [U.S.] National Bureau of Standards Special Publication 330, 1977 edition, page 1.

KELLY BARNES DAM FLOOD OF NOVEMBER 6, 1977, NEAR TOCCOA, GEORGIA

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